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(54) POLYIMIDE FILM FOR SOLAR CELL BASE AND SOLAR CELL BASE USING THE FILM

(57)Abstract:

PROBLEM TO BE SOLVED: To prepare a polyimide film for solar cell bases having a small coefficient of thermal expansion, and to provide a flexible solar cell base which shows an excellent handleability and inhibits curling and a preparation process thereof.

SOLUTION: A polyimide film for solar cell bases is prepared by using a diamine component wherein the molar ratio of 4,4'-diaminodiphenyl ether to paraphenylene diamine is from 10/90 to 40/60 and an acid dianhydride component wherein the molar ratio of a pyromellitic acid dianhydride to a biphenyltetracarboxylic acid dianhydride is from 100/0 to 75/25. The diamine component and the acid dianhydride component at a molar ratio of from 100/95 to 95/100 are allowed to react with each other in a non-protonic polar solvent to form a polyamic acid. The obtained polyamic acid is uniformly oriented to yield a self-supporting gel film which is thermally or chemically cyclodehydrated at a fixed state and further oriented in a film-delivering direction and in an orthogonal direction thereto at degrees of orientation of from 1.05 to 2.0.

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CLAIMS

[Claim(s)]

[Claim 1] The diamine component whose mole ratios of 4 and 4'-diamino diphenyl ether and a p phenylenediamine are 10 / 90 - 40/60, The acid 2 anhydride component whose mole ratios of pyromellitic acid 2 anhydride and biphenyl tetracarboxylic dianhydride are 100 / 0 - 75/25 is used. By making both react in an aprotic polar solvent so that the mole ratio of a diamine component and an acid 2 anhydride component may be set to 100 / 95 - 95/100 Heat or a chemistry target is made to do a dehydration ring closure, where the free-standing gel film obtained by forming polyamic acid and extending the obtained polyamic acid to homogeneity is fixed. The polyimide film for solar-battery substrates characterized by being formed by furthermore extending said gel film 1.05 to 2.0 times, respectively in the direction of film transport, and the direction which intersects perpendicularly with this.

[Claim 2] The polyimide film for solar-battery substrates according to claim 1 whose acid 2 anhydride component is pyromellitic acid 2 anhydride.

[Claim 3] The polyimide film for solar-battery substrates according to claim 1 or 2 whose Young's modulus the coefficient of thermal expansion of a polyimide film is 12-16 ppm/degree C, and is two or more [420kg //mm].

[Claim 4] The diamine component whose mole ratios of 4 and 4'-diamino diphenyl ether and a p phenylenediamine are 10 / 90 - 40/60, The acid 2 anhydride component whose mole ratios of pyromellitic acid 2 anhydride and biphenyl tetracarboxylic dianhydride are 100 / 0 - 75/25 is used. By making both react in an aprotic polar solvent so that the mole ratio of a diamine component and an acid 2 anhydride component may be set to 100 / 95 - 95/100 Heat or a chemistry target is made to do a dehydration ring closure, where the free-standing gel film obtained by forming polyamic acid and extending the obtained polyamic acid to homogeneity is fixed. On the front face of the polyimide film formed by furthermore extending said gel film 1.05 to 2.0 times, respectively in the direction of film transport, and the direction which intersects perpendicularly with this The solar-battery substrate characterized by having formed the amorphous silicon layer on this metal electrode, and forming a transparent electrode on this amorphous silicon after forming a metal electrode.

[Claim 5] The solar-battery substrate given in claim 4 term characterized by forming a protective layer further on said transparent electrode.

[Claim 6] The diamine component whose mole ratios of 4 and 4'-diamino diphenyl ether and a p phenylenediamine are 10 / 90 - 40/60, The acid 2 anhydride component whose mole ratios of pyromellitic acid 2 anhydride and biphenyl tetracarboxylic dianhydride are 100 / 0 - 75/25 is used. By making both react in an aprotic polar solvent so that the mole ratio of a diamine component and an acid 2 anhydride component may be set to 100 / 95 - 95/100 Heat or a chemistry target is made to do a dehydration ring closure, where the free-standing gel film obtained by forming polyamic acid and extending the obtained polyamic acid to homogeneity is fixed. A polyimide film is formed by furthermore extending said gel film 1.05 to 2.0 times, respectively in the direction of film

transport, and the direction which intersects perpendicularly with this. The manufacture approach of the solar-battery substrate characterized by forming an amorphous silicon layer on this metal electrode, forming a transparent electrode on this amorphous silicon, and forming a protective layer on a transparent electrode if needed further after forming a metal electrode in the front face of that film.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the solar-battery substrate which was used based on the small polyimide film for solar-battery substrates with a remarkable coefficient of thermal expansion, and its film and which is flexible, and handling nature is excellent in, and moreover cannot produce curl easily, and its manufacture approach.

[0002]

[Description of the Prior Art] The solar battery as photoelectromotive-force equipment which obtains power with the light energy of sunlight or others is constituted by generally using the substrate which carried out the laminating of the protective layer to the film-like base one by one further a metal electrode, a silicon layer, a transparent electrode, and if needed.

[0003] And as the substrate base of a solar battery, stainless steel and a glass plate have mainly been used by the former.

[0004] However, for the crack and cone reason, the solar battery which uses stainless steel and a glass plate as the substrate base had the big fault of being inferior to handling nature, at the time of about [that bending is impossible], manufacture, or handling.

[0005] Then, there was a problem of the big distortion between silicon with a coefficient of thermal expansion of 4 ppm [/degree C] having arisen since the coefficient of thermal expansion is large in 20-30 ppm/degree C, and being easy to curl while it has the advantage of excelling in handling nature since bending is [that specific gravity of a polyimide film is as light as 3 1.4g/cm although the polyimide film is examined as the base of a solar battery by recent years, and it is hard to be divided] easy.

[0006]

[Problem(s) to be Solved by the Invention] This invention is attained as a result of considering solution of the trouble in the conventional technique mentioned above as a technical problem.

[0007] Therefore, the object of this invention is to offer the small polyimide film for solar-battery substrates, the solar-battery substrate which is flexible, and handling nature is excellent in, and moreover cannot produce curl easily, and its manufacture approach of a coefficient of thermal expansion.

[0008]

[Means for Solving the Problem] In order to attain the above-mentioned object,

the polyimide film for solar-battery substrates of this invention The diamine component whose mole ratios of 4 and 4'-diamino diphenyl ether and a p phenylenediamine are 10 / 90 - 40/60, The acid 2 anhydride component whose mole ratios of pyromellitic acid 2 anhydride and biphenyl tetracarboxylic dianhydride are 100 / 0 - 75/25 is used. By making both react in an aprotic polar solvent so that the mole ratio of a diamine component and an acid 2 anhydride component may be set to 100 / 95 - 95/100 Heat or a chemistry target is made to do a dehydration ring closure, where the free-standing gel film obtained by forming polyamic acid and extending the obtained polyamic acid to homogeneity is fixed. It is formed by furthermore extending said gel film 1.05 to 2.0 times, respectively in the direction of film transport, and the direction which intersects perpendicularly with this.

[0009] Moreover, the solar-battery substrate of this invention forms a metal electrode in the front face of the above-mentioned film for solar-battery substrates, forms an amorphous silicon layer on this metal electrode, forms a transparent electrode on an amorphous silicon layer further, and prepares a protective layer on a transparent electrode if needed further.

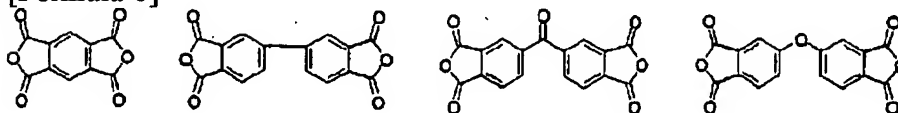
[0010]

[Embodiment of the Invention] This invention is explained in full detail below.

[0011] With the polyimide film which constitutes the substrate base of the solar-battery substrate of this invention The diamine component whose mole ratios of 4 and 4'-diamino diphenyl ether and a p phenylenediamine are 10 / 90 - 40/60, The acid 2 anhydride component whose mole ratios of pyromellitic acid 2 anhydride and biphenyl tetracarboxylic dianhydride are 100 / 0 - 75/25 is used. By making both react in an aprotic polar solvent so that the mole ratio of a diamine component and an acid 2 anhydride component may be set to 100 / 95 - 95/100 Heat or a chemistry target is made to do a dehydration ring closure, where the free-standing gel film obtained by forming polyamic acid and extending the obtained polyamic acid to homogeneity is fixed. It is formed by furthermore extending said gel film 1.05 to 2.0 times, respectively in the direction of film transport, and the direction which intersects perpendicularly with this.

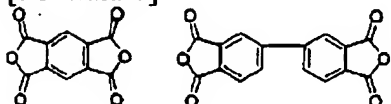
[0012] As an example of acid 2 anhydride used in the above, it is [0013].

[Formula 1]



**** is mentioned and it is [0014] especially.

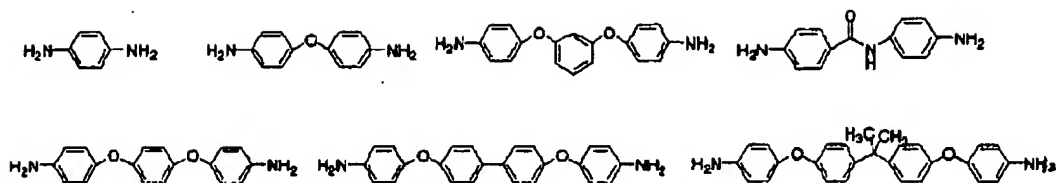
[Formula 2]



** -- it is used preferably.

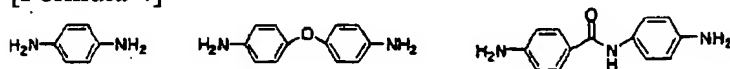
[0015] As an example of the diamine used in the above, it is [0016].

[Formula 3]



**** is mentioned and it is [0017] especially.

[Formula 4]



** -- it is used preferably.

[0018] The polymerization reaction of the polyamide acid of this invention supplies all diamine components in the system of reaction first, and after it performs the reaction of the approach of adding an acid 2 anhydride component or one diamine component, and an acid 2 anhydride component, it may use any of the approach of adding the remaining diamine components and an acid 2 anhydride component.

[0019] moreover, as an aprotic polar solvent used in the above For example, sulfoxide system solvents, such as dimethyl sulfoxide and diethyl sulfoxide, Formamide system solvents, such as N,N-dimethylformamide, N, and N-diethyl formamide, Acetamide system solvents, such as N,N-dimethylacetamide, N, and N-diethyl acetamide, Pyrrolidone system solvents, such as a N-methyl-2-pyrrolidone and an N-vinyl-2-pyrrolidone, A phenol, o-, m- or p-cresol, a xylene, a halogenation phenol, Phenol system solvents, such as a catechol, or hexamethylphosphoramide, gamma-butyrolactone, etc. can be mentioned, and although it is desirable independent or to use these as mixture, the activity of aromatic hydrocarbon still like a xylene and toluene is also possible.

[0020] As a dehydrating agent used in case the dehydration ring closure (imide-izing) of the above-mentioned polyamic acid is carried out chemically, aliphatic series acid anhydrides, such as an acetic anhydride, an aromatic series acid anhydride, etc. are raised, for example. Moreover, as a catalyst, heterocycle type tertiary amine, such as aromatic series tertiary amine, such as aliphatic series tertiary amine, such as triethylamine, and dimethylaniline, a pyridine, picoline, and an isoquinoline, is raised, for example.

[0021] In addition, in the above-mentioned polyamide acid which forms a polyimide film, 3 or less % of the weight of an inorganic filler or other polyimide etc. can be added.

[0022] It is important to face to obtain the polyimide film of this invention and to restrict the addition of acid 2 anhydride, the draw magnification of a gel film, etc. as mentioned above. By choosing such conditions, a coefficient of thermal expansion desirable as a polyimide film for solar-battery substrates of this invention can obtain a with 12-16 ppm [degree C] /and an or more [420kg //mm] 2 Young's modulus polyimide film.

[0023] The draw magnification of one of the directions which intersects perpendicularly with the direction of film transport of a gel film and this is in the inclination for Young's modulus not to give 420kg /to 2 mm, in less than 1.05

times. Moreover, it is not desirable in order to tend to tear a gel film and for productivity to fall remarkably, if one of draw magnification exceeds 2.0 times.

[0024] As for the polyimide film which is obtained in this way and used as the substrate base in the substrate for solar batteries of this invention, it is desirable that the coefficient of thermal expansion is 12-16 ppm/degree C, and Young's modulus is two or more [420kg //mm].

[0025] When the coefficient of thermal expansion of a polyimide film exceeds degree C in 16 ppm /, since the difference of a coefficient of thermal expansion becomes large between silicon layers and it becomes difficult to prevent generating of curl, it is not desirable. Moreover, since a film with the coefficient of thermal expansion smaller 12 ppm /than degree C obtained using the raw material of this invention also has low ductility, it cannot be said to be a thing desirable as a crack or an object for solar batteries for substrates which becomes empty, either.

[0026] Furthermore, even if the coefficient of thermal expansion of a polyimide film is 12-16 ppm/degree C, when the Young's modulus is less than [420kg //mm] two, since it becomes the inclination which originates in the stress produced because of the difference among few coefficients of thermal expansion with a silicon layer, and produces curl, it is not desirable.

[0027] the coefficient of thermal expansion said by this invention here -- a 50 degrees C - 200 degrees C average coefficient of thermal expansion -- meaning -- the Shimadzu make -- it is the value measured using "thermostat mechanical analyzer TMA-50."

[0028] The alloy which especially constraint does not have in the class of metal of the metal electrode formed on the above-mentioned polyimide film in the solar-battery substrate of this invention, for example, consists of two or more sorts of these metals, such as aluminum, gold, silver, copper, iron, and tin, can be illustrated.

[0029] As a transparent electrode formed on the above-mentioned amorphous silicon layer in the solar-battery substrate of this invention, conductive metals, such as an indium oxide-tin alloy, tin oxide, and indium oxide, can be illustrated.

[0030] In addition, in the solar-battery substrate of this invention, a protective layer can be further formed if needed on the above-mentioned transparent electrode, as an example of this protective layer, the light transmission of a fluoro-resin, transparence polyimide, etc. is high, and polymeric materials excellent in weatherability are mentioned.

[0031] The solar-battery substrate of this invention obtained in this way is flexible, and bendable, since it moreover is not divided at the time of manufacture or handling, distortion of about [that handling nature is excellent] and the substrate base is not caused, and the outstanding engine performance in which curl is not produced is demonstrated.

[0032] And according to the manufacture approach of the solar-battery substrate of this invention, the solar-battery substrate which has the engine performance which was excellent in the above can be manufactured efficiently.

[0033]

[Example] An example is given to below and this invention is explained to it still

more concretely.

[0034] In addition, each property in an example was measured by the following approach.

[coefficient of thermal expansion] the Shimadzu make -- "thermostat mechanical analyzer TMA-50" -- using -- 50 degrees C - 200 degrees C -- average-coefficient-of-thermal-expansion measurement was carried out.

[Young's modulus] cage en tech company make -- it measured using "tensilon RTM-250."

[Handling nature] The obtained solar-battery substrate was cut in 35mmx120mm magnitude, the feel at the time of bending this by hand was evaluated, and the following criteria estimated.

O Bending is free and it is handling nature fitness.

x It will be divided if it bends that bending is impossible and by force.

[0035] [Curl] The 35mmx120mm sample which carried out gas conditioning for 24 hours was put on the level base, the float from the base of four angles was measured, and the value which averaged this was made into the value of curl. The direction of curl wrote minus of the curl which becomes a convex, when a polyimide film was turned for the curl which becomes concave when a polyimide film is turned up to plus and reverse up.

They are 4 and 4'-oxy-dianiline 23.67g (118mmol) and p- in 500ml separable flask equipped with the example 1DC stirrer. Phenylenediamine 5.48g (50mmol) and 185.28g of N,N-dimethylacetamide were put in, and it stirred at the room temperature under nitrogen-gas-atmosphere mind. It applies 1 hour after after 30 minutes, and 35.74g (143mmol) of pyromellitic acid 2 anhydrides is thrown in in several steps. 10ml of N,N-dimethylacetamide -- using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. It adds, after stirring for 1 hour, and 10.72g (29mmol) of pyromellitic acid 2 anhydrides is thrown in over 10 minutes. 25ml of N,N-dimethylacetamide - - using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. After stirring for 12 hours, it is pyromellitic acid 2 anhydride. 18.42g (6wt%) of N,N-dimethylacetamide solutions is dropped over 30 minutes, and it stirs for further 1 hour. The polyamic acid obtained here was 3000P.

[0036] Some obtained polyamic acid is taken on polyester film, and the uniform film is formed using a spin coater. This was dipped in beta-picoline / acetic-anhydride mixed solution (50:50) for 5 minutes, and it was made to imide-ize it. The obtained polyimide gel film was heat-treated in 400-degree-C 5 minutes for 300-degree-C 20 minutes for 120-degree-C 20 minutes, and the polyimide film was obtained. The obtained polyimide was thickness:25micrometer, Young's modulus:420kg/mm², and coefficient-of-linear-expansion:14ppm/degree C.

[0037] The ion vacuum evaporation of aluminum and every 0.5 micrometers of the silicon was carried out at the obtained film, respectively, and curl was measured. The measurement result was summarized in a table 1.

4 and 4'-oxy-dianiline 22.07g (110mmol) and 207.63g of N,N-dimethylacetamide were put in into 500ml separable flask equipped with the example 2DC stirrer, and it stirred at the room temperature under nitrogen-gas-atmosphere mind. It

applies 1 hour after after 30 minutes, and 23.08g (106mmol) of pyromellitic acid 2 anhydrides is thrown in in several steps. 10ml of N,N-dimethylacetamide -- using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. After stirring for 1 hour, 3.97g (37mmol) of p-phenylene diamines is added, and 3, 3', and 4 and 10.81g (37mmol) of 4'-biphenyl tetracarboxylic dianhydride are supplied over 10 minutes. 10ml of N,N-dimethylacetamide -- using -- fine particles -- 3 and 3' adhering to a funnel, 4, and 4' - biphenyl tetracarboxylic dianhydride is washed in the system of reaction. After stirring for 12 hours, it is pyromellitic acid 2 anhydride. 16.02g (6wt%) of N,N-dimethylacetamide solutions is dropped over 30 minutes, and it stirs for further 1 hour. The polyamic acid obtained here was 3500P.

[0038] Some obtained polyamic acid is taken on polyester film, and the uniform film is formed using a spin coater. This was dipped in beta-picoline / acetic-anhydride mixed solution (50:50) for 5 minutes, and it was made to imide-ize it. The obtained polyimide gel film was heat-treated in 400-degree-C 5 minutes for 300-degree-C 20 minutes for 120-degree-C 20 minutes, and the polyimide film was obtained. The obtained polyimide was thickness:50micrometer, Young's modulus:670kg/mm², and coefficient-of-linear-expansion:12ppm/degree C. The ion vacuum evaporatio of aluminum and every 0.5 micrometers of the silicon was carried out at the obtained film, respectively, and curl was measured. The measurement result was summarized in a table 2.

4 and 4'-oxy-dianiline 23.34g (116mmol) and 198.13g of N,N-dimethylacetamide were put in into 500ml separable flask equipped with the example 3DC stirrer, and it stirred at the room temperature under nitrogen-gas-atmosphere mind. It applies 1 hour after after 30 minutes, and 19.23g (88mmol) of pyromellitic acid 2 anhydrides is thrown in in several steps. 10ml of N,N-dimethylacetamide -- using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. p- after stirring for 1 hour Phenylenediamine 2.77g (25mmol) and 10ml of N,N-dimethylacetamide are added, and 3, 3', and 4 and 14.64g (49mmol) of 4'-biphenyl tetracarboxylic dianhydride are supplied over 10 minutes. 10ml of N,N-dimethylacetamide -- using -- fine particles -- 3 and 3' adhering to a funnel, 4, and 4' - biphenyl tetracarboxylic dianhydride is washed in the system of reaction. After stirring for 12 hours, it is pyromellitic acid 2 anhydride. 15.50g (6wt%) of N,N-dimethylacetamide solutions is dropped over 30 minutes, and it stirs for further 1 hour. The polyamic acid obtained here was 3500P.

[0039] Some obtained polyamic acid is taken on polyester film, and the uniform film is formed using a spin coater. This was dipped in beta-picoline / acetic-anhydride mixed solution (50:50) for 5 minutes, and it was made to imide-ize it. The obtained polyimide gel film was heat-treated in 400-degree-C 5 minutes for 300-degree-C 20 minutes for 120-degree-C 20 minutes, and the polyimide film was obtained. The obtained polyimide was thickness:50micrometer, Young's modulus:540kg/mm², and coefficient-of-linear-expansion:16ppm/degree C. The ion vacuum evaporatio of aluminum and every 0.5 micrometers of the silicon was carried out at the obtained film, respectively, and curl was measured. The measurement result was summarized in a table 2.

4 and 4'-oxy-dianiline 31.12g (155mmol) and 276.46g of N,N-dimethylacetamide were put in into 500ml separable flask equipped with the example of comparison IDC stirrer, and it stirred at the room temperature under nitrogen-gas-atmosphere mind. It applies 1 hour after after 30 minutes, and 48.58g (151mmol) of pyromellitic acid 2 anhydrides is thrown in in several steps. 20ml of N,N-dimethylacetamide -- using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. After stirring for 12 hours, it is pyromellitic acid 2 anhydride. 25.04g (6wt%) of N,N-dimethylacetamide solutions is dropped over 30 minutes, and it stirs for further 1 hour. The polyamic acid obtained here was 3000P.

[0040] Some obtained polyamic acid is taken on polyester film, and the uniform film is formed using a spin coater. This was dipped in beta-picoline / acetic-anhydride mixed solution (50:50) for 5 minutes, and it was made to imide-ize it. The obtained polyimide gel film was heat-treated in 400-degree-C 5 minutes for 300-degree-C 20 minutes for 120-degree-C 20 minutes, and the polyimide film was obtained. The obtained polyimide was thickness:25micrometer, Young's modulus:370kg/mm², and coefficient-of-linear-expansion:25ppm/degree C. The ion vacuum evaporatono of aluminum and every 0.5 micrometers of the silicon was carried out at the obtained film, respectively, and curl was measured. The measurement result was summarized in a table 1.

4 and 4'-oxy-dianiline 31.12g (155mmol) and 276.46g of N,N-dimethylacetamide were put in into 500ml separable flask equipped with the example 2DC stirrer of a comparison, and it stirred at the room temperature under nitrogen-gas-atmosphere mind. It applies 1 hour after after 30 minutes, and 48.58g (151mmol) of pyromellitic acid 2 anhydrides is thrown in in several steps. 20ml of N,N-dimethylacetamide -- using -- fine particles -- pyromellitic acid 2 anhydride adhering to a funnel is washed in the system of reaction. After stirring for 12 hours, it is pyromellitic acid 2 anhydride. 25.04g (6wt%) of N,N-dimethylacetamide solutions is dropped over 30 minutes, and it stirs for further 1 hour. The polyamic acid obtained here was 3000P.

[0041] Some obtained polyamic acid is taken on polyester film, and the uniform film is formed using a spin coater. This was dipped in beta-picoline / acetic-anhydride mixed solution (50:50) for 5 minutes, and it was made to imide-ize it. The obtained polyimide gel film was heat-treated in 400-degree-C 5 minutes for 300-degree-C 20 minutes for 120-degree-C 20 minutes, and the polyimide film was obtained. The obtained polyimide was thickness:50micrometer, Young's modulus:370kg/mm², and coefficient-of-linear-expansion:25ppm/degree C. The ion vacuum evaporatono of aluminum and every 0.5 micrometers of the silicon was carried out at the obtained film, respectively, and curl was measured. The measurement result was summarized in a table 2.

By forming at a time 0.5 micrometers of the metal electrodes and amorphous silicons which become glass with an example of comparison 3 thickness of 5mm from aluminum with ion vacuum deposition, respectively, the false solar-battery substrate was created and the handling nature and curl were evaluated. The assessment result was written together to a table 1 and a table 2.

[0042]

[A table 1]

表 1

Nb.	ヤング率 (kg/mm ²)	熱膨張係数 (ppm/°C)	ハンドリン
実施例 1	420	14	○
比較例1	370	25	○
比較例3	6400	3.3	×

条件①：20℃,20%Rh 24時間調湿後、条件②：25℃
フィルム 25 μm, Al 0.5 μm, Si 0.5 μm

[0043]

[A table 2]

表 2

Nb.	ヤング率 (kg/mm ²)	熱膨張係数 (ppm/°C)	ハンドリング性	カール (mm) 条件① / ②
実施例2	797	6.8	○	2.3 / 1.3
実施例3	540	16	○	1.8 / 1.5
比較例2	370	25	○	23.3 / 10.5
比較例3	6400	3.3	×	0 / 0

条件①：20℃,20%Rh 24時間調湿後、条件②：25℃,95%Rh 24時間調湿後
フィルム 50 μm, Al 0.5 μm, Si 0.5 μm

[0044]

[Effect of the Invention] The film for solar-battery substrates of this invention has a small coefficient of thermal expansion, and its Young's modulus is large. Moreover, a solar-battery substrate is flexible and bendable, since it moreover is not divided at the time of manufacture or handling, distortion of about [that handling nature is excellent] and the substrate base is not caused, and the outstanding engine performance in which curl is not produced is demonstrated.

[0045] And according to the manufacture approach of the solar-battery substrate of this invention, the solar-battery substrate which has the engine performance which was excellent in the above can be manufactured efficiently.

[Translation done.]
